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Research Article

Beyond Efficiency: A Conceptual Design Framework for Sustainable Housing in Erbil

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ABSTRACT

Housing development plays a vital role in achieving sustainability goals as it is intrinsically tied to family life and faces numerous environmental challenges. The COVID-19 pandemic dramatically reshaped our understanding of home. While always a place of shelter and personal connection, the home has evolved into a truly multi-functional space. In the Middle East, a divergence in approaches to sustainability is evident, particularly in the application of resource efficiency. While certain nations have undertaken significant initiatives, cities like Erbil are still in the early stages of addressing sustainability concerns. The transition to sustainable housing can be accelerated by adopting efficient regional practices. This study aims to expand sustainable housing practices in the Middle East, fostering a deeper connection with nature while aligning with the global evolution of the home concept. A conceptual design framework is developed for application within the context of Erbil. A qualitative research method based on case analysis is adopted to achieve the study's objectives.

Keywords: Sustainability, sustainable housing, Middle East region, conceptual design framework, context of Erbil.

INTRODUCTION

The COVID-19 pandemic dramatically reshaped our understanding of home. While always a place of shelter and personal connection, the home has evolved into a truly multi-functional area. Beyond meeting basic emotional and physical needs, it now serves as a hub for work, education, recreation, and even healthcare. This shift reflects a broader trend toward integrating various aspects of life within the domestic sphere,[1] which necessitates adaptations in housing development.

Conversely, housing development plays a vital role in achieving sustainability goals, as it is closely linked to family life and faces significant environmental challenges. Despite progress, developing countries continue to face significant housing challenges. Sustainable architecture is still in its early stages, often shaped by global trends while overlooking local contexts, specific circumstances, and traditional practices.[2] Access to regional experiences facilitates the adoption of technologies and designs that are tailored to local contexts and physical capabilities.[3]

Within the Middle East region, a divergence in approaches to sustainability is evident. Certain nations have undertaken significant initiatives, often in collaboration with international firms. In contrast, architects in other countries face obstacles in adapting to established global frameworks. The transition to sustainable housing could be accelerated by adopting successful practices in the region, which typically focus on the sustainable and effective use of resources, particularly in response to high energy consumption, especially within the domestic sector, as well as water scarcity. Restoring local identity can also be seen as another motivating factor behind these practices.[4]

Erbil City, the capital of the Northern region of Iraq, has taken significant strides toward enhancing environmental sustainability across various sectors, aiming to curb greenhouse gas emissions. This ambitious endeavor is outlined in a detailed action plan developed in partnership with the United Nations Development Program and supported by the European Union. Guided by a forward-looking vision for the city's future, the initiative emphasizes reducing emissions, advancing clean energy solutions, and strengthening resilience against climate change impacts. A critical focus is the housing sector, which stands as the largest emitter, contributing approximately 50% of the total emissions in the Erbil Governorate. This high percentage is largely attributed to the sector's heavy dependence on non-renewable energy sources for heating

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and cooling. Despite these efforts, Erbil remains in the early stages of its sustainability journey, with substantial work still required to achieve its environmental goals.

This study aims to advance and expand sustainable housing practices in the Middle East by fostering a deeper integration with nature, enhancing the quality of living environments, and ensuring alignment with the global evolution of modern housing concepts. To achieve these objectives, a comprehensive conceptual design framework is developed for practical application within the local context of Erbil City.

RESEARCH METHODOLOGY

This study employed a case study analysis, informed by a comprehensive literature review, to achieve its research objectives. The literature review identified established design models for sustainable housing in the Middle East and key design factors for the regional design framework, emphasizing the potential for fostering a stronger connection with nature while aligning with the evolving global concept of the home. In addition to data collection, which included site visits and direct observation of the traditional houses in Erbil, an analysis of international sustainable housing projects provided insights into both traditional and innovative global solutions.

LITERATURE REVIEW

The Sustainability Paradigms and Design Concepts

Since the mid-20th century, numerous design concepts in sustainable architecture have emerged in response to environmental challenges associated with buildings. These solutions generally fall into one of two paradigms.[5] [Table 1].

Advocates of technological sustainability refer to the 1987 report as evidence that no major shift is needed in the current development path. The report advocates for a technical approach to economic growth that focuses on better management and advanced technology. This paradigm is based on the idea that the environmental crisis is caused by inefficient resource use. Consequently, it promotes design concepts aimed at achieving high-performance buildings with a reduced environmental impact using energy and resources efficiently, prioritizing human needs, and approaching nature through a mechanistic lens.

In contrast, ecological sustainability is grounded in different assumptions, challenging the typical optimistic view of our shared future. This paradigm, inspired by the principles of ecology, sees nature as a dynamic, interconnected web where interdependent entities organize, maintain themselves, exchange information and energy, and evolve in harmony with their surroundings. Proponents of this approach believe that sustainability challenges are technical and environmental but also psychological and spiritual. They argue that the environmental crisis stems from humanity's disconnection from, and disregard for, the intricate web of life, and thus advocate for limits on technology, material consumption, pressure on the biosphere, and irresponsible human behavior.[5]

Table 1: Sustainability paradigms[5] (adapted)

Sustainability paradigm	Nature model	Problem-solving method	The relation with the local context
Technological sustainability	Mechanistic model	Advanced technology	Global scope – ignoring the local context
Ecological sustainability	Ecological model	Limitations in scale, technology, and materials	Culture and place is a critical asset

The evolution of the sustainability concept in design paralleled an improvement in the relationship between humans and nature. Over time, the idea of human interaction with nature shifted from a purely utilitarian perspective to one of utilitarianism combined with reconciliation and eventually to a model based on partnership and mutual benefit[6] [Figure 1].

Low-impact design is an anthropocentric approach to sustainability that aims to safeguard nature for the well-being of humans. It developed as a means to address environmental harm caused by human actions, using scientific reasoning to understand the environment and determine the appropriate corrective measures.

While the adoption of technology plays a crucial role in sustainable development, it is argued that it is inadequate for ensuring long-term sustainability. This is because it fails to restore the connection between nature and humanity in a world increasingly characterized by environmental degradation and social and psychological isolation.[7] Even worse, this approach is a process of standardization, which means that particular local conditions and competing forms of local knowledge tend to be ignored.[8,9]

Ecological design is a method of strengthening the connection between nature and culture by aligning with natural processes to minimize environmental impact.[10] This integration with nature can be either passive or active.[11] Active ecological approaches, in contrast to passive ones, deliberately cultivate a non-anthropocentric relationship with nature. This can be biocentric, focusing on the living components of the environment, or ecocentric, which values ecosystems as a whole, encompassing both biotic and abiotic elements.

According to Mange, environmental challenges are too complex to be solved through technical measures alone. By integrating the technological approach with the ecological perspective, which emphasizes the connection between humans and nature, we can address these challenges more effectively.[12]

The Sustainable Home

To be sustainable, houses should be designed to achieve maximum well-being for the occupants while minimizing the environmental burden.[13] Well-being is a multifaceted interplay of mental, emotional, and social health, in addition to physical health. Studies[14,15] propose a comprehensive model for a healthy home that integrates design strategies leveraging natural elements to enhance a building's environmental performance. These studies emphasize the synergy between bioclimatic design principles and biophilic design attributes

to achieve optimal human health. This approach fosters a profound connection between occupants and nature while maintaining low energy consumption.

Bioclimatic design is a climate-responsive design based on the reduction of consumption of non-renewable energy and minimizing such mechanical systems.[16] Several studies[16-20] have touched on measures to implement these strategies, which sometimes overlap to address more than one issue or to carry out the strategy, which can be summarized as shown in Table 2.[2]

On the other hand, Biophilic design, a passive ecological approach, fosters a connection between humans and nature, promoting health and well-being.[21] Kellert identified three types of experiences with nature that represents the fundamental categories of the biophilic design framework. These include the direct experience of nature, the indirect experience of nature, and the experience of space and place[22] [Figure 2]. Unlike the technical approach, human interventions focus on incorporating natural elements into the built environment to enrich the user experience and improve the overall efficiency of systems.[7]

Sustainable Home Models of the Middle East

Middle Eastern countries, like much of the developing world, tend to prioritize human survival over the preservation of nature, highlighting the need for a stronger focus on the fundamental concepts of "needs" outlined in the Brundtland Commission report.[23] In this region, sustainable architecture practices are narrowed down to three efficiency approaches. One is revivalist, the other is progressive, and there is a hybrid combining the two.[4] The revivalist design approach aligns with Košir's concept of "Symptomatic Bioclimatic Design," which emphasizes the use of vernacular architecture, known for its inherent energy efficiency, as a basis for developing climate-responsive built environments. This approach leverages established solutions to create spaces that both address environmental factors and reinforce local identity.[19] These solutions consist of strategies, methods, and components that enhance natural cooling, a process that controls indoor temperatures during the summer by utilizing the environmental characteristics of the site.[4,19] However, traditional solutions are insufficient to meet the demands of people in the present era.

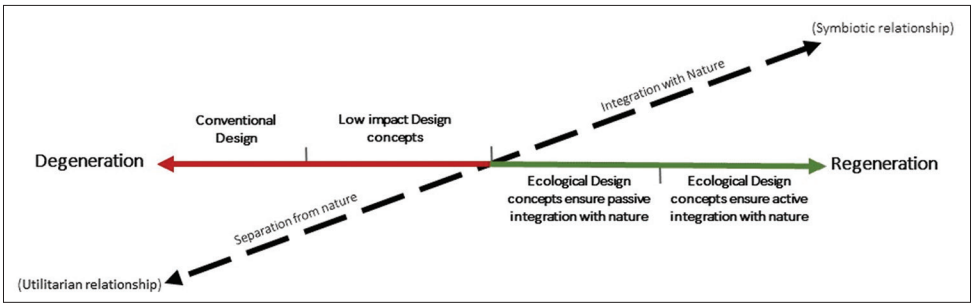

Figure 1: The development of the human-nature relationship in environmental design concepts (Author)

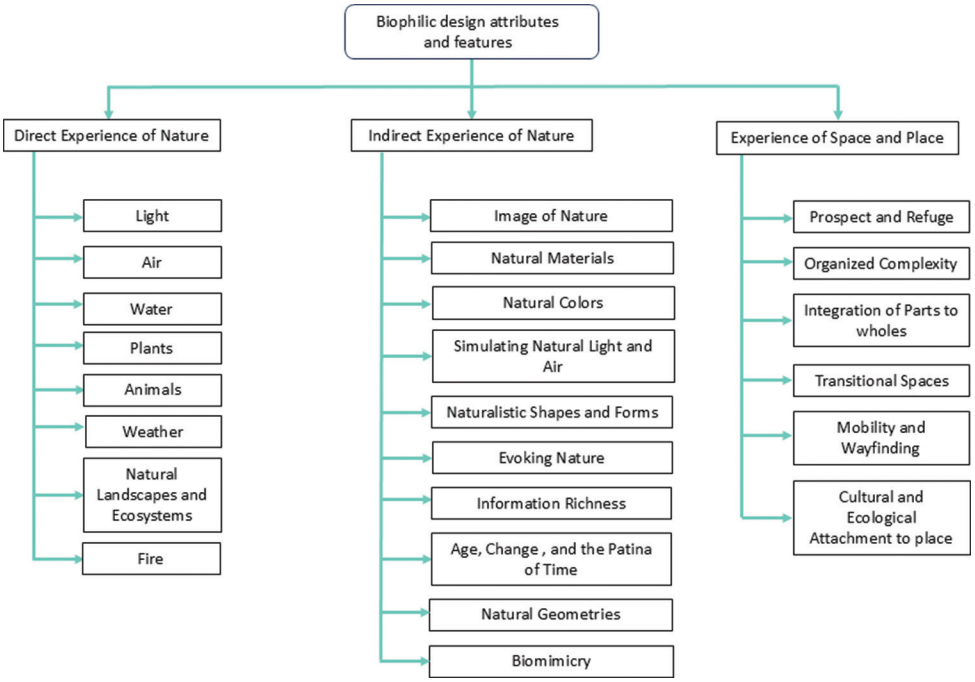

Figure 2: Biophilic design attributes and features[22] (Adapted)

Table 2: Bioclimatic design strategies and measures[16-20] (Author)

Focus issue	Bioclimatic design strategies	Measures
Thermal comfort (Heating strategies)	Heat retention	Insulation and thermal break
		• Resistance thermal insulation
		• Capacitive thermal insulation
		Building massing
		Space zoning and orientation
		The structural and thermal properties of the building envelope
		Convective heat exchange
		• Airtight envelope
	Delay periodic heat flow store	Using construction materials with high thermal mass (e.g., Masonry wall)
		Earth sheltering
	Promote heat gain	Space zoning and orientation South-oriented windows
		Built form color
		Openings design (window size, location, and details
		Passive solar system
		• Direct solar gain
		• Distributed thermal mass
		• Concentrated thermal mass
		• Indirect solar gain
		• Trombe wall
		• Sunspace
		• Roof pond
		• Isolated solar gain
		• Thermosiphon
		Convective heat exchange
		• Ventilation heating
	Minimize external airflow	• Siting and shaping a building to minimize wind exposure
		• Providing windbreaks
Thermal comfort (Cooling strategies)	Heat gain prevention	• Shading techniques
		• Shading by building form
		• Shading by external obstructions
		• Shading by trees and vegetation
		• Fixed or movable shading devices
		• Shading by glazing optical properties
		Space zoning and orientation to prevent heat gain
		Minimize the building surfaces exposed to the summer sun
		Opening's design (window size, location, and details
		Built form color
		Radiant barrier
		Vertical landscape
		Thermal insulation
		• Reflective thermal insulation
		• Capacitive thermal insulation
		• Resistance thermal insulation

(*Contd...*)

Table 2: (*Continued*)

Focus issue	Bioclimatic design strategies	Measures
		Material surface (film coefficient)
	Heat removal	Wind and natural ventilation (cross, stack, hybrid)
		Earth as a heat sink
		Evaporative heat exchange
		• Direct evaporative cooling (presence of water)
		• Indirect evaporative cooling
		• The presence of vegetation economizer-cycle evaporative cooling system
		Radiative heat exchange
		• Roof pond
		• High emissivity surfaces
		Building massing
		• Spread-out building
Visual comfort	Maximum usage of daylight	• Large shaded south windows
Air quality	Improving oxygen content	Properly designed ventilation
		The introduction of greater amounts of green plants into the built environment

The progressive approach stands in stark contrast to the revivalist approach. It focuses on implementing the latest technologies for resource efficiency without regard for local knowledge. Resource efficiency involves utilizing the Earth's finite resources in a sustainable way while minimizing environmental impact. In housing, this is demonstrated through technologies such as energy efficiency, water conservation, indoor environmental quality improvement, and control systems.[24] Nonetheless, these advanced technologies must be adapted to fit local contexts to provide the desired comfort and relevance, a challenge often hindered by insufficient knowledge and innovation.

The hybrid design model was developed to address the issues arising from the two extreme approaches [Figure 3], aiming to create a built environment that is much more ecologically conscious while retaining a strong sense of self-identity. In this approach, local and global cultures work in tandem to define the regional identity.

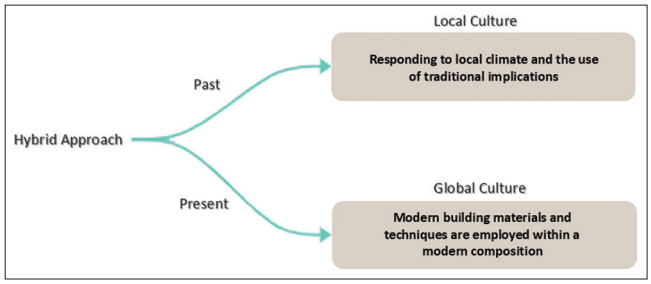

Figure 3: Hybrid sustainable design approach of the Middle East region (Author)

Developing the Framework

Aligning with global environmental concerns and the challenges of contemporary life, which have introduced a new concept for housing, the Middle East's approach to sustainable home design must shift toward a more holistic model that fosters a deeper connection with nature. By incorporating biophilic design into the process, homes can transcend mere efficiency, benefiting both humans and the environment.

The Arab Middle East's hybrid sustainable design model, which blends traditional energy efficiency methods with cutting-edge resource efficiency technologies, could be significantly enhanced by incorporating biophilic design, taking a crucial step toward promoting well-being [Figure 4]. The resulting design model is an ecological design that builds an active relationship with nature[25,26] and brings a periodic and limited integration with nature.[11]

Vernacular architecture inspires successful projects by offering time-tested solutions, as exemplified by Hassan Fathy's work. It is believed that traditional elements could be seamlessly integrated into modern designs by reinterpreting them while preserving their core function.[27] Indigenous tangible and intangible knowledge offers a solid foundation for both biophilic and bioclimatic design – two interconnected approaches that leverage natural elements such as natural ventilation and daylighting.[28] The study of vernacular architecture and settlements provides essential insights for biophilic design, as well as an understanding of how local populations engage with biophilia. It also offers proven solutions to challenges related to thermal comfort and energy efficiency.

An analytical bioclimatic approach can also be employed to assess the effectiveness of traditional passive features within a given system.[19] On the other hand, contemporary sustainable housing projects, introduced through regional practices, can help identify the latest resource efficiency technologies that

have been refined and adapted to specific building typologies and regional contexts [Figure 5].

Operating the Framework

The residential architecture of Erbil City

Erbil is the capital of the Kurdish region of Iraq. The residential architecture development in this city can be traced, starting with the traditional houses built on top of the Erbil citadel, which is the most important historical feature of the city, which used to include most of the human social activities in ancient times, through the surrounding neighborhoods that arose later. Erbil Citadel is a large urban complex located in the center of Erbil and built on top of a hill (archaeological mound) [Figure 6], resulting from the accumulation of historical layers throughout the millennia.[29]

At present, the citadel is located in the heart of Erbil city. The population growth of the citadel as a result of natural increase and migration, with its limited area in addition to economic and social development, led to the spread of the population outside its borders and the emergence of new neighborhoods surrounding the citadel, such as Arabs, Khanka, Tajil, and Sadoonawa. During later periods, the city witnessed a dramatic development that led to the increase and expansion of city neighborhoods based on a group of circular road networks that are penetrated by radial streets, which made the citadel become their center.

Thus, the history of the Erbil house can be divided into two prominent periods:

- The ancient historical period between the middle of the nineteenth century and the first half of the twentieth century is the time to which the majority of the historical buildings that exist in Erbil city belong.[29]
- The contemporary period, which is the post-2003 period, where Erbil city witnessed economic and urban prosperity associated with a large growth in the housing sector

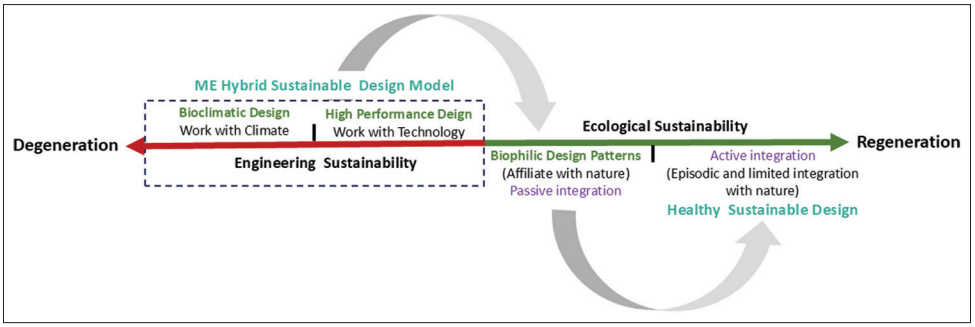

Figure 4: The proposed design model for sustainable healthy housing in the Middle East (Author)

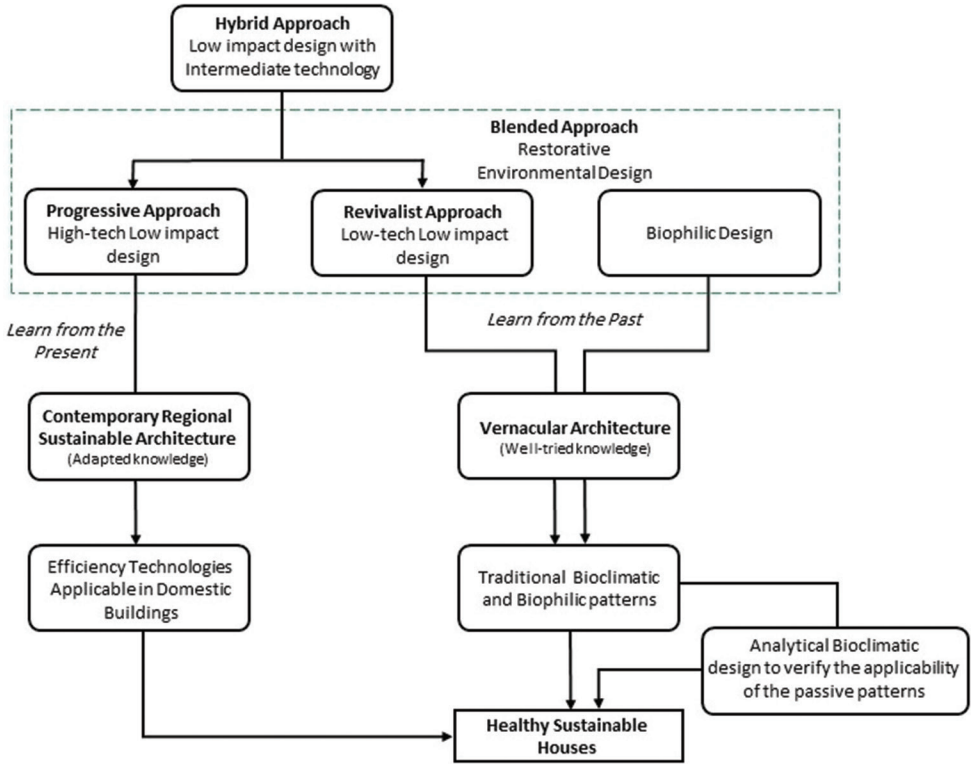

Figure 5: A Conceptual design framework for sustainable healthy housing in the Middle East (Author)

through the emergence of new residential neighborhoods and modern residential complexes, both horizontally and vertically on a large scale.

The issuance of laws and decisions since 2006 to meet the city's demand for housing has led to the emergence of many housing projects. In addition to single-family housing, multi-family housing projects have emerged as a quick response to the needs of the growing housing market, as recommended by the Ministry of Construction and Housing in the northern part of Iraq, especially in the city center, due to land efficiency.[31]

Figure 6: Erbil citadel[30]

Investigating the health patterns of the Erbil Citadel houses

The majority of the houses in the citadel are courtyard homes, characterized by mud roofs, short-span timber roofs, and brick walls. Kamal and Al Shehab argue that bioclimatic architecture represents a modern evolution of strategies already embedded in vernacular architecture, enhanced by human-controlled systems that were absent in traditional methods.[32] On the other hand, Yahya asserts that traditional courtyard homes found in Middle Eastern cities are inherently biophilic structures, employing various techniques to satisfy the residents' innate desire to connect with nature. This connection helps explain why these homes have remained central to people's way of living for centuries, maintaining their cultural significance and sustainable functionality despite evolving social and environmental changes.[33]

A survey of the Erbil Citadel houses was conducted to identify the bioclimatic and biophilic design strategies adopted [Appendix 1], which can be introduced as passive health attributes applicable to housing projects.

Deriving the latest technologies

Yang regarded the adoption of passive measures as the initial stage in the ecological building design process, followed by the integration of technologies.[16] Seven leadership in energy and environmental design (LEED) -certified sustainable housing projects were selected for innovative sustainable design features [Appendix 2]. These projects include Mosler Lofts, Seatle, USA; the Residential Building of the Masdar

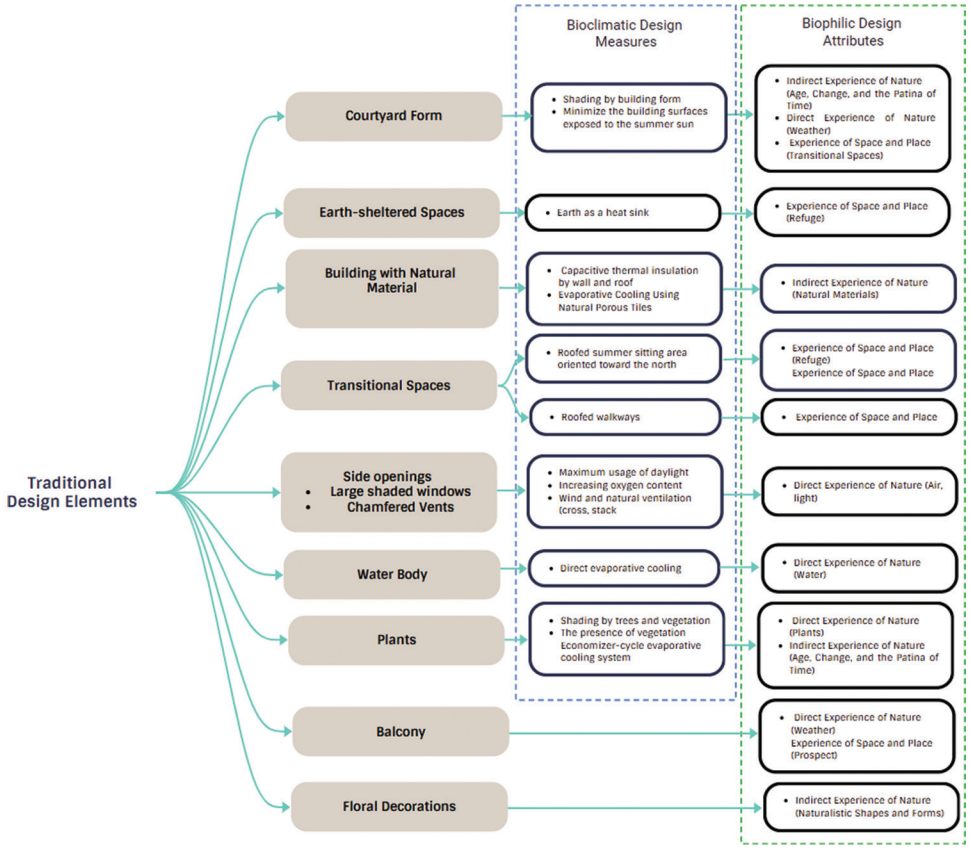

Figure 7: Passive health attributes applicable to housing projects in Erbil city (Author)

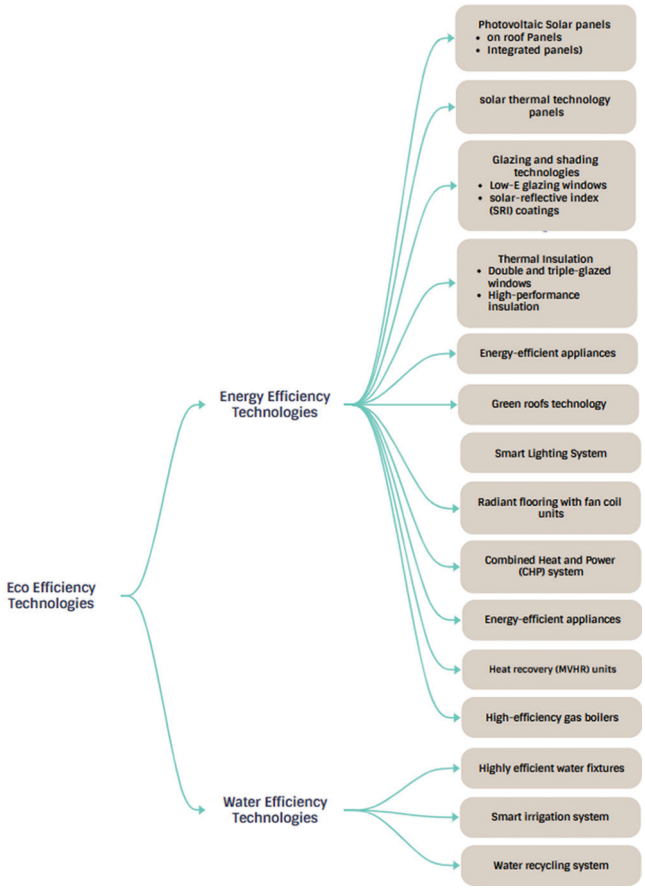

Figure 8: Eco-efficiency technologies applicable to housing projects (Author)

Institute of Science and Technology in Abu Dhabi, UAE; Etihad Eco Residence in Abu Dhabi, UAE; Zero Place – apartments in New York, USA; Bosco Verticale in Milan, Italy; DEWA Accommodation Complex in Dubi, UAE; the Beddington Zero Energy Development in Hackbridge, South London; Senior Housing Project in Los Angeles, USA; and DEWA Accommodation Complex in Abu Dhabi, UAE. The extracted technologies apply to housing projects.

RESULTS AND DISCUSSION

Applying the proposed approach to the Erbil case formulates a design language for sustainability and healthy housing, leveraging local architecture to obtain passive design strategies [Figure 7] and contemporary sustainable housing projects as a source of sustainability innovations [Figure 8]. The research demonstrated that all traditional environmental elements function not only as bioclimatic design tools but also as biophilic aspects [Figure 8], emphasizing their direct connection to nature and thermal performance.

CONCLUSION

The study introduces a design framework that can be used by designers and developers in Middle East cities to create healthy, sustainable housing projects. Organic biophilic design attributes and features in housing developments take Middle Eastern practices beyond the efficiency paradigm. It introduces benefits for both occupants and the surrounding natural environment. In addition to enhancing the spiritual and psychological health of the residents, incorporating greenery into the built environment helps biodiversity flourish, thus improving the local ecology. Traditional passive strategies and the latest technologies have been introduced to Erbil to achieve local healthy and sustainable housing, thus achieving an integration that balances local architectural heritage with global sustainability innovations.

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APPENDICES

Appendix 1: The traditional design elements, measures, and attributes of Erbil citadel houses (Author)

The traditional element	Description	Bioclimatic design measures	Biophilic design attributes and features
Courtyard form	• Living spaces are organized around an open central space. This design maximizes the interplay of light and shadow, creating dynamic visual experiences that evolve throughout the day. 	• Shading by building form • Minimize the building surfaces exposed to the summer sun	• Indirect experience of nature • (Age, change, and the patina of time) • Direct experience of nature (weather) • Experience of space and place (transitional spaces)
Earth-sheltered spaces	• A semi-basement provides social and climatic shelter. 	• Earth as a heat sink	▪ Experience of Space and Place (Refuge)
Building with natural material	• Mudbrick and stone were the primary building materials of Erbil Citadel houses. 	• Capacitive thermal insulation	▪ Indirect Experience of Nature (Natural Materials)
	• Thick tree trunks (joists), mate, thin tree trunks (joists), Mud (soil, chopped straw, and water) 	• Capacitive thermal insulation	▪ Indirect Experience of Nature (Natural Materials)
Transitional spaces	• Roofed summer sitting area oriented toward the north 	• Shading by building form	▪ Experience of Space and Place (Refuge) ▪ Experience of Space and Place (Transitional Spaces)
	• Roofed walkways 	• Fixed shading devices	▪ Experience of Space and Place ▪ (Transitional Spaces)

(*Contd...*)

Appendix 1: (*Continued*)

The traditional element	Description	Bioclimatic design measures	Biophilic design attributes and features
Side windows	• Living spaces open onto the courtyard with large shaded windows • Small ventilation windows in the walls overlooking the courtyard, along with high ceilings, encourage natural ventilation 	• Maximum usage of daylight • Increasing oxygen content • Wind and natural ventilation (cross, stack)	▪ Direct Experience of Nature (Air, light)
Arcade	• Covered passageway leads to living spaces 	• Fixed shading devices	▪ Experience of Space and Place (Transitional Spaces)
Brick paving	• Traditional paving bricks tile the courtyard floor, and their porous nature allows them to absorb and hold water	• Direct evaporative cooling	▪ Indirect Experience of Nature (Natural Materials)
Water body	• A Water fountain constitutes an integral component of the courtyard 	• Direct evaporative cooling	▪ Direct Experience of Nature (Water)
Balcony	• The peripheral houses open to the outside through balconies 		▪ Direct Experience of Nature (Weather) ▪ Experience of Space and Place (Prospect)
Plants	• The use of plants in the courtyard 	• Shading by trees and vegetation • The presence of vegetation Economizer-cycle evaporative cooling system	• Direct experience of nature (plants) • Indirect experience of nature (age, change, and the patina of time)
Floral patterns	• The walls and ceilings were decorated with floral patterns 		Indirect experience of nature (naturalistic shapes and forms)

Appendix 2: Eco-Efficiency Technologies Used in the Selected Sustainable Housing Projects (Author)

#	Building name	Year	Location	Certificate	The applied technology
1	Mosler lofts	2007	Seattle, United States	LEED silver	1. The roof is super-insulated (R-45) and contains extensive planting areas 2. Occupancy sensors control lighting 3. LED lights are used for exterior lighting 4. High efficiency boilers
2	The residential building of the Masdar Institute of Science and Technology in Abu Dhabi	2010	Abu Dhabi, UAE	LEED gold	1. On the roofs solar panels 2. Solar thermal technology panels 3. The facade is well insulated and sealed, covered with a recycled aluminum sheet in the same color as the mashrabiya rose-red 4. Low-e double glazing
3	Etihad eco residence	2017	Abu Dhabi, UAE	LEED platinum	1. High-performance insulation 2. Heaters Solar hot water systems provide three-quarters (76%) of the community's water demand 3. Solar-reflective index (SRI) coatings reflect light away from the surface of a building with minimal absorption 4. The apartments are equipped with highly energy-efficient appliances 5. The use of highly efficient water fixtures that contribute to reducing potable water consumption
4	Bosco Verticale in Milan, Italy	2014	Milan, Italy	LEED gold	1. All apartments are heated and cooled by four geothermal heat pumps 2. Radiant flooring with fan coil units offers heating and cooling in the apartments. The radiant floors can be fed directly by groundwater via a heat exchanger 3. About 200 meters of PV panels are delivered to Bosco Verticale. This accounts for around 2% of the expected electrical consumption 4. A drop irrigation system is used to reduce water usage 5. The wastewater is collected in a storage tank and is afterward utilized entirely in the daily watering of the planted facade 6. Wall insulation is higher than the local code (0.17W/m2K vs. 0.34W/m2K). Both U-values and g-values are 25% higher than the local construction code 7. The windows include thermal-fractured aluminum frames with argon-filled, Low-E double glazing 8. The irrigation system is outfitted with moisture and temperature sensors
5	Zero place–apartments	2022	New York, USA	LEED platinum	1. High-efficiency appliances, including clothes washer and dryer 2. Geothermal system 3. 180 kW solar array 4. High-performance insulation material 5. High-performance windows
6	Senior housing project	2022	Los Angeles, USA	LEED gold	1. Water-saving plumbing fixtures. 2. Green roof technology 3. High-efficiency ductless mini-split heat pumps 4. High-performance windows 5. High-performance insulation material 6. A solar domestic hot water system
7	DEWA accommodation complex	2024	Abu Dhabi, UAE	LEED platinum	1. High-performance insulation material 2. Energy-efficient lighting and appliances 3. Water-saving plumbing fixtures 4. Rooftop solar photovoltaic system

LEED: Leadership in energy and environmental design